

Missouri Herpetological Association



Newsletter

Number 30
2017

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MISSOURI HERPETOLOGICAL ASSOCIATION NEWSLETTER NO. 30

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INTRODUCTION

The Thirtieth Annual Meeting of the **Missouri Herpetological Association** was held 16-17 September 2017 at the **Reis Biological Station**, in Crawford County, Missouri. This organization is designed to provide herpetologists in Missouri and surrounding states with an opportunity to meet and exchange ideas regarding current efforts in research and other professional activities. High on the list of priorities is to provide students, involved in research at either the graduate or undergraduate level, (1) the chance to interact with senior herpetologists, and (2) an outlet to present, in a semi-formal setting, the results of their labors.

This newsletter is the result of a decision made at the inaugural meeting to provide a means of publicly acknowledging papers presented at this and subsequent annual meetings. Further, the newsletter will inform the herpetological community of new distribution records of Missouri's herpetofauna, additions to the bibliography dealing with the state herpetofauna and provide an outlet for the publication of short notes dealing with the natural history of Missouri amphibians and reptiles.

ANNOUNCEMENTS

31st Annual Meeting of the Missouri Herpetological Association

The Thirty-First Annual Meeting of the Missouri Herpetological Association will be held 29-30 September 2018. Next year we will return to the **Bull Shoals Field Station** in Taney County near Forsyth, Missouri. The "call for papers" will be sent electronically in mid-July. For more information, please contact **Jeff Briggler** at:

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SUMMER COURSE IN HERPETOLOGY BIOLOGY OF AMPHIBIANS AND REPTILES

What: A field herpetology course, BIOL 4260 Biology of Amphibians and Reptiles

Where: Reis Biological Station near Steelville, MO

When: May 21 - June 9, 2018

Instructor: Dr. Mark Mills, Missouri Western State University

This will be a field-based course in herpetology emphasizing the amphibians and reptiles of Missouri. Classes run all day Monday through Friday with exams on Saturdays. We will do extensive fieldwork at and near Reis Biological Station, but I also have plans for short field trips to other locations in the state (e.g., St. Louis Zoo). Housing (cabins with bunks) and three meals a day are provided. If you have questions about the course content or structure, please contact Dr. Mark Mills at mmills3@missouriwestern.edu. For questions concerning registration, fees, lodging, etc., please contact Dr. Tom Valone at valone@slu.edu or go to the following link:

<https://www.slu.edu/arts-and-sciences/biology/reis-biological-station/summer-courses.php>



MHA on the Net

The Association has an official site on the Internet.

Point your browser to <http://mha.moherp.org/> for copies of current and past publications and to view photos and information from past field trips and meetings. Send ideas, suggestions, comments, and content to the Webmaster (webmaster@moherp.org).

Cover: Western Massasauga (*Sistrurus tergeminus*). The snake was observed September 30, 2017 crossing the perimeter road at Loess Bluff (Squaw Creek) NWR, Holt County, MO. Photo by Richard Daniel.

**Abstracts of Papers Presented at the 30th
Annual Meeting of the
Missouri Herpetological Association**

**Reis Biological Station
16-17 September 2017**

MYSTERY SALAMANDER FROM MISSOURI

Tom Anderson

University of Kansas, Lawrence, KS

Intraspecific phenotypic variation is common in amphibians. Such variability can range from discrete traits, such as adult phenotypes in some ambystomatid salamanders, to more continuous traits, such as trophic polymorphisms and variability in coloration. Some examples of variability in coloration can also stem from developmental anomalies, such as albinism and other skin patterning (e.g. leucistic or melanistic forms). Because individuals are rarely observed, it is often difficult to discern how common such variation is in natural populations, or whether other undocumented phenotypic variants exist within populations. Here, I report on a previously unreported developmental anomaly for *Ambystoma annulatum* (Ringed Salamander). Two individuals that had been collected as eggs from two different populations separated by 90km, developed into large unpigmented individuals that remain in a larval state for more than four years. Each individual exhibited logistic growth, hitting asymptotes at approximately 60 mm SVL. Both individual exhibited no visual signs of maturation, which was confirmed by dissection. My current working hypotheses is that each individual had a malfunctioning thyroid, which limited both pigmentation and metamorphosis. No individuals to my knowledge have been collected from natural populations but would be difficult to detect, especially in light-colored ponds, where larvae already are light-colored.

**TRANSCRIPTOMIC SIGNATURES REVEAL BIOMARKERS FOR
UNDERSTANDING AMPHIBIAN STRESS**

Timothy A. Clay, Michael L. Treglia, Michael A. Steffen, Ana Lilia Trujano-Alvarez, and Ronald M. Bonett
University of Tulsa, Tulsa, OK

Global biodiversity is decreasing at an alarming rate and understanding the factors that negatively impact populations is fundamental to addressing this epidemic. Diverse biomarkers have been developed to monitor human physiology and health, yet relatively few of these methods have been applied to wildlife. Plasma glucocorticoids are often used to assess stress in vertebrates, but these hormones can be extremely dynamic and impractical to quantify in small organisms. However, many genes are differentially regulated in response to physiological stressors, offering a potentially rich source of informative biomarkers for stress. We tested for transcriptomic differences in tail tissues of stream-dwelling salamanders chronically exposed to corticosterone at

different temperatures. We found significant transcriptional differences that were unique in response to temperature or corticosterone. Several of the differentially regulated genes are known to be involved in immune and stress responses in model systems. Furthermore, additional experiments show that their expression patterns were robust to differences in age, life history, and tissue regeneration. Our study suggests that transcriptomic patterns harbor stressor specific signatures that can be highly informative for monitoring wild populations.

INFLUENCE OF SEX, TERRITORIAL OWNERSHIP, AND SPECIES ON AGGRESSION IN TWO SPECIES OF SALAMANDER

Colton Lynn and Alicia Mathis
Missouri State University, Springfield, MO

Territorial disputes are common among terrestrial woodland salamanders (genus *Plethodon*). Southern red-backed and Ozark zigzag salamanders are territorial congeners that are ecologically similar, but zigzag salamanders show substantially higher levels of activity in laboratory trials. We tested whether the two species also differed in aggressive behavior and whether aggressive behavior differed between males and females. Focal individuals set up territories, and then conspecific same-sex intruders were introduced. For both residents and intruders, zigzag salamanders showed significantly higher overall levels of aggression; sex influenced the behavior of the intruders, with males showing lower aggression in both species. In addition, for both residents and intruders, nose taps (neutral, chemosensory behavior) did not differ significantly between species. However, female intruders of both species nose tapped more frequently than males. The overall higher levels of aggressive behavior by zigzag salamanders may be a consequence of their higher general activity levels. The higher levels of aggressive and chemosensory behavior by intruder females may indicate a difference in territorial strategies between sexes.

BEHAVIORAL FLEXIBILITY IN THE PRAIRIE LIZARD, *Sceloporus consobrinus*

Han Hoekzema, Stephanie Ruck, and Manuel Leal
University of Missouri, Columbia, MO

Previous studies have shown behavioral flexibility in lizards, that is, the capacity to solve a novel problem, which demonstrates cognitive abilities commonly associated with higher cognitive processes. To further investigate this mechanism in lizards, we presented the prairie lizard, (*Sceloporus consobrinus*) with a novel detour task in a semi-natural setting. If *S. consobrinus* exhibits behavioral flexibility, we expect them to solve the detour task. Furthermore, the number of errors should decrease as individuals learn the task. To confirm that an individual was indeed learning, we looked at phase completion and the number of errors it took for the subject to successfully solve a trial. Out of the 23 lizards tested, 95% completed phase 1 (i.e., habituation phase), 47% completed phase 2 (i.e., which required individuals to detour around a transparent barrier placed in the middle of the apparatus), and 5% completed phase 3 (i.e., which required individuals to associate a pattern on the apparatus with an entrance). Our results demonstrate that *S. consobrinus* can solve a novel problem and thereby has the capacity to be behaviorally flexible. Furthermore, individual errors decreased over time strongly suggesting that learning contributed to the ability of lizards to solve the task.

DOES “BODY CONDITION” ACCURATELY PREDICT ENERGY RESERVES IN LIZARDS?

Matt Gifford and Chris Robinson
University of Central Arkansas, Conway, AR

“Body condition” is a metric frequently calculated by herpetologists in ecological and life history studies. This metric is generally taken as a proxy for energy reserves or overall physiological condition. Recently, several studies have questioned the validity of this metric and others have devised alternatives thought to better reflect the underlying physiological state of individuals. Such metrics have been favored, because direct measurement of stored energy generally requires euthanasia and solvent extraction of lipids from dried tissues. Recently, technology has been developed that putatively allows researchers to measure body composition in animals via magnetic resonance. If validated, such technology opens the door to a variety of studies in ecology and life history that were virtually impossible. In this study, I provide validation of this technology for two species of lizard and illustrate some of the exciting potential offered by it.

DO OKLAHOMA SALAMANDERS RESPOND TO THE SCENT OF AQUATIC PREDATORS AND ALARM CUES AFTER METAMORPHOSIS?

Shannon Johnson and Alicia Mathis
Missouri State University, Springfield, MO

Aquatic-stage amphibians can recognize their most common predators, either innately or through learning. Do these individuals retain recognition of aquatic predators after metamorphosis to a terrestrial stage? Oklahoma salamanders, *Eurycea tynnerensis*, have both metamorphic (aquatic larvae, terrestrial adults) populations and paedomorphic (aquatic larvae and adults) populations. Paedomorphic individuals should experience stronger selection to retain recognition of aquatic predator post-metamorphosis than metamorphic individuals. Prey individuals can detect predators directly via chemical cues released from the predator, or indirectly via alarm cues released when another individual (conspecific or heterospecific) is attacked. We tested whether paedomorphic and metamorphic adults respond to (a) chemical cues from a fish predator (sculpin) and (b) alarm cues from a syntopic prey fish (darters) that have the same predators as the salamanders. Our preliminary data indicate a tendency for paedomorphic adults to respond to both the sculpin cue and the darter alarm cue with a fright response, as predicted. However, terrestrial metamorphic adults also responded to the fish cue with fright (longer latency to move, increased “look small” posture) and responded to the darter alarm cue by increasing Edge behavior. Therefore, terrestrial adults appear to respond to cues from aquatic predators and heterospecific members of the same prey guild even though they would only indicate a predatory threat for the adults during the breeding/egg-laying period.

BIOCHEMICAL MECHANISMS INFLUENCING COUNTER-GRADIENT VARIATION IN LIZARD DEVELOPMENT

Angela N. Lenard and Matthew E. Gifford
University of Central Arkansas, Conway, AR

Counter-gradient variation occurs across environmental gradients when environmental and genetic influences on a phenotype oppose each other. An example of this phenomenon is the inherently faster growth rates observed in animals from higher latitudes compared to their low latitude conspecifics. Enhanced growth is hypothesized to be advantageous for ectotherms from cooler climates to compensate for a shorter growing season and depressed metabolism. *Sceloporus consobrinus*, the prairie lizard, is an excellent system to study the underlying mechanisms of counter-gradient variation in growth due to its broad latitudinal range. This study compares *S. consobrinus* from Missouri to those in Arkansas and provides evidence for counter-gradient variation in embryonic development. Lizards from Missouri hatched out larger and exhibited shorter incubation times than those from Arkansas. At the same stage of development, embryos from Missouri were larger than those from Arkansas and had less residual yolk, but no differences in metabolic enzymatic activity were observed. This study provides additional support that yolk assimilation rates play a major role in counter-gradient development.

FIRST SEASON RESULTS ON THE SPATIAL ECOLOGY AND HABITAT SELECTION OF PYGMY RATTLESNAKES (*Sistrurus miliarius*) IN SOUTHWESTERN MISSOURI

Dylan Maag and Brian Greene
Missouri State University, Springfield, MO

Despite a wide distribution throughout the southeast United States, pygmy rattlesnakes (*Sistrurus miliarius*) have received little research attention relative to other rattlesnake species. I captured a total of 33 pygmy rattlesnakes at the Drury-Mincy Wildlife Area (DMWA) and retained 14 large individuals (mostly gravid females) for a radiotelemetry study. Snakes were primarily encountered during evening road driving surveys and were rarely seen with any other technique. Pygmy rattlesnakes are widespread at DMWA where they were encountered in forest, savannah, and glade habitats. Snakes selected sites with more tree canopy and close to cover, such as small fallen logs and shrubs, while avoiding areas with sparse cover. All telemetrically monitored snakes were relatively sedentary and occupied very small (0 – 2.6 ha) home ranges. Gravid snakes were especially immobile during gestation, often limiting all activity to a few m² area. Births occurred in early-mid August with maternal attendance observed for several litters. An additional season of telemetry data is ongoing to derive comparative data for males and non-gravid females and assess variation in microhabitat selection among adult snakes differing in sex and reproductive condition.

BEHAVIORAL RESPONSES OF COTTONMOUTHS TO CONSPECIFIC CLOACAL GLAND SECRETIONS DURING FEEDING EVENTS

Alex Meinders and Brian Greene
Missouri State University, Springfield, MO

All snakes possess cloacal glands from which they secrete malodorous substances during predatory encounters. These secretions have been suggested to facilitate a variety of possible chemosensory communication functions. The two main hypotheses proposed for the function of snake musk gland secretions are predator deterrence and as a social alarm cue. However, experimental evidence addressing these hypotheses is limited. The recent discovery of cryptic sociality in pitvipers has sparked renewed interest in the alarm cue hypothesis. I tested the alarm cue hypothesis by examining behavioral responses of juvenile cottonmouths (*Agkistrodon piscivorus*) for evidence of threat sensitivity during feeding trials. Preliminary results are consistent with snakes being wary when exposed to musk as evidenced by elevated mean latencies to feed, time spent immobile, and tongue-flick rate, compared to control trials. These findings will be presented along with a description of other planned experiments intended to evaluate musk gland functionality.

SURVEYING HERPETOFAUNA ON GLADES THROUGHOUT THE MISSOURI OZARKS: PRELIMINARY FINDINGS

Mark S. Mills, Chris D. Watson, Bethany Bolander
Missouri Western State University, St. Joseph, MO

Glades are open, rocky habitats surrounded by forest in the uplands of the Ozarks of Missouri and Arkansas. In addition to being rocky, glades are characterized by having shallow soils and often face south or southwest, making them warm and dry. In Missouri, glades serve as “islands” of drier prairie or desert habitat in an area dominated by oak-hickory forest, making them important habitats for a variety of what are often thought of as more western species. Glade indicative species include a wide variety of vegetation, invertebrates, birds, and central to this presentation, amphibians and reptiles. We are part of a team that is surveying glades located on Missouri Department of Conservation land throughout the Ozarks of Missouri. We have surveyed 30 glades in our first year (2016-2017), documenting a wide variety of species such as flat headed snakes (*Tantilla gracilis*) and pickerel frogs (*Rana palustris*). We will attempt to correlate species richness and abundance, particularly of glade indicative species such as the collared lizard (*Crotaphytus collaris*) and the variable ground snake (*Sonora semiannulata semiannulata*), with various attributes of these glade sites, including dominant rock type, fire management history, and location. The information gathered from this first year of surveys, as well as data collected in the upcoming years of this ongoing study, will in turn be used to help inform the Missouri Department of Conservation of the overall health of glades throughout the Ozarks and will allow for better informed management plans of these glade units.

MATERNAL EFFECTS OF STRESS ON OFFSPRING PHENOTYPE IN *Sceloporus consobrinus*

Marci Polett and Matthew E. Gifford
University of Central Arkansas, Conway, AR

Maternal effects of stress have been found to contribute to offspring phenotype and potentially influence offspring survival and fitness in many different species. Specifically, stress hormones like corticosterone (CORT) contributed by the mother in an embryonic environment have been shown to influence offspring morphology, growth, physiology, and behavior. Current studies are inconclusive as to the impact CORT has on offspring and how CORT can differently impact the development of males and females. Using prairie lizards, *Sceloporus consobrinus*, as a model, I determined how exposure to CORT in the embryonic environment influenced offspring morphology, growth, survival in the lab, and “personality”. Data from the 2016 breeding season indicate some sex-specific differences in hatchling body size among treatments as well as potential differences in early laid and late laid clutches. After further examination of CORT effects using treatments within one and two standard errors of the mean during the 2017 breeding season, data show CORT is not responsible for offspring phenotype for *Sceloporus consobrinus*. These results indicate further studies are needed to help us understand the mechanism behind maternal CORT transfer as well as any potential long-term effects on offspring.

THERMALLY-INDUCED SIGNAL PLASTICITY DOES NOT REFLECT INDIVIDUAL PERFORMANCE VARIATION ACROSS TEMPERATURES IN PRAIRIE LIZARDS

Christopher D. Robinson and Matthew E. Gifford
University of Central Arkansas, Conway, AR

Physiological changes in response to environmental cues are not uncommon. Temperature has a strong effect on many traits, such that traits follow stereotyped thermal performance curves in response to increasing temperature. The prairie lizard, an abundant ectotherm throughout the central United States, has thermally sensitive, blue abdominal and throat patches. Currently, the role of these patches is not well understood. In this study, we set out to investigate whether individual plasticity in patch color mimicked individual plasticity in sprint speed (do they covary?) and if the plasticity in these two patches signal redundant or complementary information, testing competing hypotheses suggested for the evolution of multiple signals. We found that although patch hue exhibited stereotyped thermal performance curves, thermal plasticity in patch color did not mimic thermal plasticity in performance at the individual level. But we did find strong support for the hypothesis suggesting that these two patches signal redundant information through covariation of color across temperatures. The importance of better understanding the function of individual variation cannot be overstated and, overall, more work is needed to better understand the ultimate mechanisms underlying signal plasticity in this species and others.

**DIFFUSIBLE IODINE-BASED CONTRAST-ENHANCED COMPUTED
TOMOGRAPHY (diceCT), A NOVEL APPROACH TO THE COMPARATIVE
ANATOMY OF DEGENERATE NEURAL STRUCTURES;
EXAMPLES FROM THE CENTRAL TEXAS *Eurycea***

Ruben U. Tovar^{*1}, Paul M. Gignac², and Ronald M. Bonett¹

¹The University of Tulsa, Tulsa, OK

²Oklahoma State University Center for Health Sciences, Tulsa, OK

The paedomorphic *Eurycea* salamander clade of Central Texas exemplifies a continuum of morphological characteristics associated with aquatic-subterranean living: the surface-dwelling Texas salamander (*E. neotenes*) exhibits typical optic anatomy and acuity; the intermediate Comal blind salamander (*E. tridentifera*) maintains reduced but non-functional eyes; and the obligate subterranean Texas blind salamander (*E. rathbuni*) has an incompletely developed optic system. This genus represents a transformation series of karst phenotypes and a potentially exemplar system for using comparative approaches to understand vertebrate ocular evolution in the face of relaxed selective pressures. More than a century ago Eigenman described ocular histology in *E. rathbuni* adults as a focal troglodyte; yet, neither the extent of optic-nerve persistence in this taxon nor its congeners has been documented since. In this study, we employed gross and micro-scale imaging techniques to elucidate features of *Eurycea* optic anatomy with a particular interest in the central nervous system. Specimens from aforementioned taxa were fixed with 100% EtOH, contrast-enhanced with alcoholic iodine (I₂E), micro-CT-scanned, and digitally reconstructed using 3D rendering software for comparison to histological sections. Here we report on the 3D, internal soft-tissue systems of the eye in each taxon, documenting habitat-specific configurations of optic musculature and neuroanatomy for the first time. *E. rathbuni* surprisingly appears to retain complete bilateral optic nerves despite its lack of mid-line decussations associated with an optic chiasm.

NEW HERPETOLOGICAL DISTRIBUTION RECORDS FOR MISSOURI IN 2017

Richard E. Daniel¹, Brian S. Edmond² and Jeffrey T. Briggler³

¹Division of Biological Sciences, University of Missouri, Columbia, MO 65211

²Computer Services, Missouri State University, Springfield, MO 65897

³Missouri Department of Conservation, P.O. Box 180, Jefferson City, MO 65102

The following list represents new county records accumulated or brought to our attention since the publication of Daniel and Edmond (2017). Publication of these records extends our knowledge of the amphibians and reptiles found within the state of Missouri. In addition, recipients of this list have the opportunity to update checklists and distribution maps. Finally, the publication of this list allows us to acknowledge the contributions of the many individuals who have contributed information or specimens.

The records listed below represent the first report of the species within a given county and are based on catalogued voucher specimens or photographs deposited in a public institution. Distribution records are presented in the standardized format of Collins (1989): common and scientific name, county, specific locality (unless withheld for species of concern), legal description of locality, date of collection, collector(s), catalogue number and institution where the specimen is deposited. Scientific and common names follow Crother (2017).

Specimens reported in this note have been deposited in the Missouri State University Herpetology Collection, Springfield, MO (MSU) or the Dean E. Metter Memorial Collection, University of Missouri, Columbia, MO (UMC). Unless otherwise indicated, all distribution records are documented by post-metamorphic/hatchling fluid preserved specimens.

We would like to extend our appreciation to A. Braun, D. Hoisington, J. Hubert, T. Jay, T. Jessen, J. Karel, C. Montgomery for contributing photographs that were used in this note.

AMPHIBIA: ANURA (FROGS AND TOADS)

AMERICAN TOAD

Anaxyrus americanus

Adair Co.: Sugar Creek Conservation Area (T61N R16W Sect. 12); 5 October 2017; A. Chapman (digital image, UMC 3306P).

EASTERN NARROW-MOUTHED TOAD

Gastrophryne carolinensis

Cape Girardeau Co.: MDC Southeast Regional Office (T31N R13E Sect. 22); 25 June 2017; A. Braun (digital image, UMC 3260P).

GREEN FROG

Lithobates clamitans

Adair Co.: Sugar Creek Conservation Area (T61N R16W Sect. 2); 5 October 2017; A. Chapman (digital image, UMC 3307P).

BOREAL CHORUS FROG

Pseudacris maculata

Adair Co.: Truman State University Farm (T62N R15W Sect. 17); 4 June 2017; A. Chapman (digital image, UMC 3264P).

REPTILIA: SQUAMATA (SNAKES)

EASTERN COPPERHEAD

Agkistrodon contortrix

Perry Co.: Seventy-Six Conservation Area (T35N R13E Sect. 29); 21 August 2017; T. Jessen (digital image, UMC 3301P).

TIMBER RATTLESNAKE

Crotalus horridus

Lincoln Co.: Cuivre River State Park (T49N R1E Sect. 18); 12 September 2016; M. Orsmy (digital image, UMC 3251P).

NORTHERN WATERSNAKE

Nerodia sipedon

Atchison Co.: 8.45 km ESE Westboro (T66N R38W Sect. 16); 8 October 2017; R. Daniel (digital image, UMC 3287P).

Holt Co.: Loess Bluff (Squaw Creek) National Wildlife Refuge (T61N R39W Sect. 15); 15 April 2017; R. Daniel (digital image, UMC 3230P).

BULLSNAKE

Pituophis catenifer

Newton Co.: Rt. M, 6.16 km SE Granby (T25N R30W Sect. 14/15); 8 April 2017; T. Jay (digital image, UMC 3253P).

GRAHAM'S CRAWFISH SNAKE

Regina grahamii

Caldwell Co.: Rt. A, 0.65 km N Shoal Creek (T57N R26W Sect. 34); 15 April 2017; R. Daniel (UMC 8964).

RED-BELLIED SNAKE

Storeria occipitomaculata

Monroe Co.: Mark Twain Lake, Indian Creek Recreation Area (T55N R8W Sect. 25); 24 July 2017; B. Edmond, J. Edmond (digital image, UMC 3399P).

COMMON GARTERSNAKE

Thamnophis sirtalis

Atchison Co.: Rt. B, 11.6 km NNW Tarkio (T66N R40W Sect. 10); 8 October 2017; R. Daniel (digital image, UMC 3289P).

LINED SNAKE

Tropidoclonion lineatum

Bates Co.: Battle of Island Mound State Historical Site (T40N R32W Sect. 35); 18 August 2016; D. Hoisington (digital image, UMC 3040P).

Caldwell Co.: Rt. B, 0.37 km N Jct. Co. Rd. 334 (T56N R27W Sect. 26); 15 April 2017; R. Daniel (UMC 8962).

REPTILIA: TESTUDINES (TURTLES)

SPINY SOFTSHELL

Apalone spinifera

Adair Co.: Chariton River at Co. Rd. 224C (T62N R16W Sect. 15); 16 September 2017; Kelly Lovera (digital image, UMC 3273P).

OUACHITA MAP TURTLE

Graptemys ouachitensis

Cedar Co.: Cedar Creek at Rt. K (T35N R27W Sec. 26); 7 October 2017; B. Edmond (digital image, UMC 3445P).

Monroe Co.: Mark Twain Lake (T55N R8W Sec. 25); 22 July 2017; B. Edmond (digital image, UMC 3397P).

Stone Co.: Table Rock Lake (T23N R24W Sec. 2); 9 September 2017; B. Edmond, J. Edmond, M. Bowe (digital images, UMC 3425P).

FALSE MAP TURTLE

Graptemys pseudogeographica

St. Clair Co.: Clear Creek at Co. Rd. SW-1371 (T37N R28W Sec. 29); 7 October 2017; B. Edmond (digital image, UMC 3448P).

ALLIGATOR SNAPPING TURTLE

Macrochelys temminckii

Greene Co.: James River at Lake Springfield Dam (T28N R21W Sect. 20); 25 April 2008; N. Wray, D. Moll, M.B. Anders (photo voucher, MSU 2492).

RIVER COOTER

Pseudemys concinna

Oregon Co.: Mark Twain National Forest, Eleven Point River at Turner Mill (T24N R3W Sec. 3); 12 August 2017; B. Edmond, T. Van Someren (digital image, UMC 3418P).

EASTERN MUSK TURTLE

Sternotherus odoratus

Barton Co.: Prairie State Park (T32N R33W Sect. 16/17); 17 May 2010; D. Hoisington (digital image, UMC 3252P).

Perry Co.: Perryville Community Lake (T35N R10E Sect. 26); 28 June 2017; J. Karel (digital image, UMC 3261P).

RED-EARED SLIDER

Trachemys scripta

Cedar Co.: Cedar Creek at Rt. K (T35N R27W Sec. 26); 7 October 2017; B. Edmond (digital image, UMC 3443P).

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NATURAL HISTORY NOTES

TAIL BIFURCATION IN AN AMERICAN BULLFROG, *Lithobates catesbeianus*, TADPOLE

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Morphological abnormalities of amphibians are being reported at an increasing rate, with a particular interest in metamorphic frogs with missing, malformed or duplicated appendages (e.g. Lannoo, 2008). Bifurcated tails of tadpoles have been reported less frequently, although reports exist from diverse taxonomic families (reviewed in Henle *et al.*, 2012). Reports of bifurcated tails in tadpoles are typically based on one or two individuals within a population (Henle *et al.*, 2012), including an observation of two *Lithobates catesbeianus* tadpoles with bifurcated tails from unknown populations in New York state (Sherwood, 1891). Here we report the first observation of a tail bifurcation from a known locality, wild population of *L. catesbeianus* tadpole from Missouri.

On 26 March 2017, we captured a Gosner stage 36 *L. catesbeianus* tadpole (2.9 cm body length; 7.5 cm tail length; 4.22 g) with a tail bifurcation (Fig. 1) on private property 5.5 km northwest of Koeltztown, Osage County, Missouri. Specimen identification was verified by R. Daniel and deposited in the Dean E. Metter Memorial Collection, University of Missouri, Columbia, Missouri (UMC 8961). The bifurcation originated at 4.5 cm from the base of the tail and the two tail segments were equal in length (Fig. 1). The bifurcation did not appear to interfere with tadpole locomotion.

Tail bifurcations have been observed after tail compression or partial amputation (Henle *et al.*, 2012), which results in tail duplication due to hyper-regeneration triggered by mechanical trauma (Lynn, 1950). Tail bifurcation can also be due to temperatures outside of the normal range, chemical treatment, ultrasound, radioactivity, or egg retention (reviewed in Henle *et al.*, 2012). The cause of tail bifurcation in the case reported here cannot be determined, although there was no evidence of trauma at the site of bifurcation.

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Figure 1. Captured *L. catesbeianus* tadpole exhibiting tail bifurcation.

RECORDS OF SNAKES FROM THE PREMIUM STANDARD FARMS SCOTT-COLBY FACILITY, DAVIESS/GRUNDY COUNTY, MISSOURI

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Premium Standard Farms (PSF) Scott-Colby facility on the boundary of Daviess and Grundy County, Missouri, is a commercial pork production operation with restricted access. The property encompasses a reservoir with a man-made rip-rap dam near the northeast corner. Five distinct habitats, including open field, open rocky slopes, hardwood forest, riparian, and covered rocky slopes, make up the 21-ha area of interest surrounding the man-made reservoir. Open field consists of occasionally mowed grass in areas of varying slope. Open rocky slopes, which consist primarily of rip-rap with some natural boulders, exposed rock ledges and scattered trees (*Gleditsia triacanthos* L. and *Platanus occidentalis* L.) are located at the north end of reservoir. Covered rocky slopes consist of natural boulders and rock ledges and are found under moderate to heavy forest canopy. A large portion of the site is covered by secondary hardwood forest.

A small area of riparian habitat exists along the stream below the spillway of the dam. The goal of this study was to examine the snake community associated with an artificial rip-rap dam and man-made reservoir in north central Missouri.

A capture-mark-recapture study was conducted from late March through November of 2008, 2009 and 2010. Surveys were made by actively searching suitable habitats on foot, including turning natural cover objects. At each site of capture, time, weather and location (UTM coordinates using a Garmin GPS II Plus, Garmin Intl., Olathe, KS) were recorded. Snakes were processed in the field or transported to the lab at Truman State University for processing. Each snake was processed by measuring snout-vent length (SVL; ± 0.1 cm) and tail length (± 0.1 cm) using a squeeze box. Mass (± 0.1 g) was determined using an electronic balance. Sex was determined by cloacal probing. Reproductive condition and stage class were recorded. All snakes were individually marked with an intraperitoneal PIT Tag if over 20 g or batch marked by clipping the tip of the tail if under 20 g. In addition, rattlesnakes received a painted code on their rattle based on the PIT tag sequence to reduce handling in the field for identification. All snakes were released at the site of capture as soon as possible, typically within two days. Separate t-tests were used to compare SVL and mass between sexes within each species. Chi-square analysis was used to determine if sex ratio was significantly different from 1M:1F. No statistical analyses were conducted for species with fewer than 5 adult captures.

We made a total of 237 captures of 204 individual snakes from 8 species. *Lampropeltis triangulum* (n = 65) and *Crotalus horridus* (n = 61) made up the majority of initial captures. Six additional species included *Diadophis punctatus* (n = 38), *Coluber constrictor* (n = 7), *Thamnophis sirtalis* (n = 7), *Nerodia sipedon* (n = 16), *Carphophis vermis* (n = 4), and *Pantherophis obsoletus* (n = 6) were captured.

Lampropeltis triangulum (Red Milk Snake). Sixty-five individuals (34M:31F) were captured with 14 recaptures. Demography was adult skewed (4YOY:2J:59A). Adult sex-ratio was not significantly different from 1:1 ($X^2 = 0.02$, $p = 0.90$). The average SVL of adults was 38.86 cm (± 20.08) with no significant difference between males (38.38 cm ± 20.88) and females (39.33 cm; ± 19.63 ; t-test, $t = 0.18$, $p = 0.858$). Three Red Milk Snakes (2M:1F) exceeded the current vouchered maximum length in Missouri (the largest two males measured 74.0 cm SVL/84.2 cm TL and 84.1 cm SVL/93.6 cm TL and the female measured 73.9 cm SVL; Anderson, 1965; Edmond and Daniel, 2001). The average body mass of adults was 47.26 g (± 58.63) with no significant difference between males (44.92 g; ± 61.02) and females (49.53 g; ± 57.18 ; t-test, $t = 0.30$, $p = 0.77$). However, adult females had a significantly higher mass at a given SVL than adult males (ANCOVA; $F_{1,1} = 6.32$, $p < 0.001$).

Crotalus horridus (Timber Rattlesnake). Sixty-one individuals (30M:31F) were captured with 5 recaptures. Demography was neonate skewed (39YOY:6J:16A) because females were held in captivity until parturition and neonates were included in analysis. Adult sex-ratio was not significantly different from 1:1 ($X^2 = 1.00$, $p = 0.32$). The average SVL of adults was 90.86 cm (± 13.82) with a significant difference between males (103.68 cm; ± 14.51) and females (83.16 cm; ± 5.08 ; t-test, $t = -3.34$, $p = 0.016$). The average body mass of adults was 709.34 g (± 332.56) with no significant difference between males (1012.95 g; ± 444.34) and females (557.53 g; ± 86.43 ; t-test, $t = -2.27$, $p = 0.08$). However, adult females had a significantly smaller mass at a given SVL than adult males (ANCOVA; $F_{1,1} = 37.32$, $p < 0.001$).

Diadophis punctatus (Ring-necked Snake). Thirty-eight individuals (24M:14F) were captured with 13 recaptures. Demography was adult skewed (0YOY:1J:37A). Adult sex-ratio was not significantly different from 1:1 ($X^2 = 3.27$, $p = 0.07$). The average SVL of adults was 25.51 cm (± 3.65) with no significant difference between males (24.92 cm; ± 3.74) and females (26.57 cm; ± 3.36 ; t-test, $t = 1.36$, $p = 0.18$). The average body mass of adults was 8.38 g (± 2.67) with no significant difference between males (7.77 g; ± 2.32) and females (9.46 g; ± 2.99 ; t-test, $t = 1.75$, $p = 0.09$). However, adult females had a significantly higher mass at a given SVL than adult males (ANCOVA; $F_{1,1} = 4.42$, $p = 0.04$).

Coluber constrictor (North American Racer). Seven individuals (4M:3F) were captured and none were recaptured. Demography was 0YOY:3J:4A. Adult sex-ratio was equal to 1:1. The average SVL of adults was 66.62 cm (± 18.22) with males (59.40 cm; ± 4.81) appearing to be shorter than females (73.85 cm; ± 27.65). The average body mass of adults was 177.22 g (± 176.39) with males (101.53; ± 17.13) appearing to lower mass than females (252.91 g; ± 264.82).

Thamnophis sirtalis (Common Gartersnake). Six adult individuals (3M:3F) were captured and none were recaptured. The average SVL of adults was 47.28 cm (± 9.02) with no apparent difference between males (48.30 cm; ± 3.26) and females (46.27 cm; ± 13.78). The average body mass of adults was 55.82 g (± 23.35) with males (40.82 g; ± 10.07) appearing to weigh less than females (78.31 g; ± 17.05).

Nerodia sipedon (Common Watersnake). Fifteen individuals (3M:12F) were captured with none recaptured. Demography was 2H:6J:7A. All adults captured were female. Female adult SVL averaged 49.38 cm (± 19.86) and body mass averaged 229.47 g (± 237.04).

Carphophis vermis (Western Worm Snake). Four individuals (3M:1F) were captured and none were recaptured. Demography was 0H:2J:2A. Adult sex-ratio was 1M:1F. The average SVL of adults was 24.70 cm (± 2.40). The one female had a SVL of 26.40 cm and the male had SVL of 23.00 cm. The average body mass of adults was 10.87 g (± 5.84). The adult female had a mass of 15.00 g and the male a body mass of 6.74 g.

Pantherophis obsoletus (Western Rat Snake). Six individuals (5M:1F) were captured with no recaptured animals. Demography was 0H:1J:5A. Adult sex-ratio was 4M:1F. The average SVL of adults was 93.76 cm (± 19.15). The one female captured had a SVL of 122.80 cm and male SVL averaged 86.50 cm (± 11.74). The average body mass of adults was 243.81 g (± 151.80). The adult female weighed 122.80 g and males body mass averaged 274.06 g (± 156.91).

We captured 8 species of snake during the survey, although 11 species of possible occurrence in the area were not captured (Daniel and Edmond, 2014). A previous survey of Grundy County indicated that 17 snake species were found in this county, representing 52.9 % more than our survey (Crawford, 1964). Young of year (YOY) snakes made up a large demographic group across species, comprising 46.6 % (n = 95) of all captured individuals. Open rocky slope was the most used and surveyed habitat, generating 88.2% (n = 180) of captures.

The Simpson Diversity index of snakes at this site was 0.232. PSF diversity was similar to that calculated for snakes at Wakonda State Park (0.205; Lennon and Montgomery, 2012), which was represented by only four snake species. Simpson diversity at PSF was lower than calculated for snakes at University of Kansas Natural History Reservation (0.425; Fitch, 1982). Simpson diversity indicates that the PSF snake community is less diverse and less even than the more natural University of Kansas Natural History Reservation community.

Our results were limited by the methods we used for surveying the study site. By limiting our methods to visual encounters and turning cover objects it is likely that we missed some species that were actually present, such as *Heterodon platirhinos* and *Lampropeltis calligaster*, and underrepresented the abundance of some species encountered, such as *Diadophis punctatus* and *Coluber constrictor*. Incorporating funnel traps, pitfall trap, and artificial coverboard arrays to more thoroughly sample all habitats at the site would likely increase the documented species richness and abundance at our study site.

Acknowledgements: We thank the staff at Premium Standard Farm Scott-Colby farm, especially L. Lash and J. Helton for logistical support, the Missouri Department of Conservation and Missouri Department of Natural Resources for permits, and Truman State University for IACUC approval and financial support.

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REPTILES AND THEIR USE OF ARTIFICIAL COVER OBJECTS IN RECLAIMED AND REMNANT PRAIRIE HABITATS

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Abstract.—During 2013–2015, we placed three types of artificial cover objects (tarpaper, wood, and tin) at twelve sites in reclaimed and remnant prairie at Jerry Smith Park in Jackson County, Missouri and checked them regularly for the presence of reptiles. Of the eight-species encountered, none were species associated exclusively with prairies, indicating that the remnant was too small to sustain populations and that intervening development precluded recolonization from the nearest extant prairies. Although tarpaper and plywood was used more frequently than tin by most species, including those for which we had substantial data, no differences in the use of cover objects were significant.

Artificial cover objects (ACOs) provide a nondestructive, efficient method for monitoring cryptic herpetofauna, yet few studies have conducted side-by-side comparisons of novel ACO materials (MacNeil 2013). ACOs are important for tracking preferred habitats for certain species. Different kinds of arrangement are evident at different spatial scales, and particular arrangements indicate degree of environmental heterogeneity, social interactions among individuals, or both (Gregory 2004). Different ACOs (e.g., tarpaper, wood, and tin) have unique qualities that should attract different species.

Few artificial cover board studies have examined the efficacy of different kinds of coverboards at attracting specific herpetofaunal species (Coleman and Sievert 2013). Assessment of the relative success of ACO types across multiple studies is hindered by vast discrepancies in study design and duration (MacNeil 2013). Because of this, finding multiple direct and comparable results is difficult. However, determining which species prefer which ACOs is important in facilitating field-based research studies.

Animals that could be forced to aggregate at available sites might represent no more than mutual tolerance among individuals (Gregory 2004). Nevertheless, such “social” gatherings could identify trends in the types of species that cohabitate under ACOs that are most accessible or most convenient.

Native prairies are shrinking ecosystems in the United States, a phenomenon largely attributable to agricultural expansion and urbanization (e.g., Samson and Knopf 1994; Wilgers and Horne 2006). The loss of habitat contributes to the loss of wildlife native to those prairies (Gibbons et al. 2000). Affected reptilian species include those associated primarily or exclusively with prairies (i.e., prairie-limited) and for which records exist in the area where a study was conducted as well as those species that readily exploit prairie

habitat but are not restricted to such conditions (Table 1). Prairie restoration can increase quality habitat available for prairie species, and remnant and restored prairies provide habitats essentially similar to those on native prairies (Rizzo 2001). Consequently, native prairie species should be able to survive and even thrive in remnant and restored prairie habitats of adequate size and quality.

Jerry Smith Park, a 360-acre expanse of open rolling hills, patches of forest, a three-acre lake, and the largest remaining tract of remnant prairie in Kansas City, was acquired by Kansas City, Missouri in 1975, became part of the Kansas City Park System in 1976, and was managed as an educational farm until 1984 (<<https://www.bridgingthegap.org/jerry-smith-park/>>). Restoration efforts, including tree removal, prescribed burns, and invasive species control were initiated in 1998, with the first burn in 2004.

In this study, we tested two predictions: (1) Reptilian species in reclaimed and remnant prairie habitat at Jerry Smith Park will resemble the species composition of native prairies in the region; and (2) reptilian species will use different cover objects (wood, tin, or tarpaper) at different frequencies, probably using wood most frequently because tin and tarpaper will overheat during the summer.

Materials and Methods

We established twelve sites in prairie habitats in Jerry Smith Park (Fig. 1). Eight sites were in restored prairie and four in remnant prairie. Using methods of Coleman and Sievert (2013), we placed tin, tarpaper, and wood coverboards at each site, providing a total of thirty-six cover objects. We checked sites two to three times per week during the spring and fall, but less frequently (usually only once per week) during the summer, when herpetofaunal activity declined. We removed the ACOs during the winter to allow for prairie management (e.g., burning, mowing) but placed them at the same sites in the following spring.

Table 1. Reptilian species of western Missouri that are known to associate with prairie habitats. “Prairie-limited” indicates species associated primarily or exclusively with prairies at least in this area; “Prairie” indicates a close association with prairies or other open habitats (largely aquatic species that might follow streams into prairie habitat are not included). Data from Johnson (2000), Collins et al. (2010), and Daniel and Edmond (2014).

Eastern Collared Lizard (<i>Crotaphytus collaris</i>)	Prairie
Common Five-lined Skink (<i>Plestiodon fasciatus</i>)	
Great Plains Skink (<i>Plestiodon obsoletus</i>)	Prairie-limited
Northern Prairie Skink (<i>Plestiodon septentrionalis</i>)	Prairie-limited
Western Slender Glass Lizard (<i>Ophisaurus attenuatus</i>)	Prairie
Western Wormsnake (<i>Carphophis vermis</i>)	
North American Racer (<i>Coluber constrictor</i>)	Prairie
Eastern Coachwhip (<i>Coluber flagellum</i>)	Prairie
Ring-necked Snake (<i>Diadophis punctatus</i>)	
Prairie Kingsnake (<i>Lampropeltis calligaster</i>)	Prairie
Speckled Kingsnake (<i>Lampropeltis holbrooki</i>)	
Eastern Milksnake (<i>Lampropeltis triangulum</i>)	
Great Plains Ratsnake (<i>Pantherophis emoryi</i>)	Prairie
Western Ratsnake (<i>Pantherophis obsoletus</i>)	
Bullsnake (<i>Pituophis catenifer</i>)	Prairie-limited
DeKay’s Brownsnake (<i>Storeria dekayi</i>)	
Plains Gartersnake (<i>Thamnophis radix</i>)	Prairie
Common Gartersnake (<i>Thamnophis sirtalis</i>)	
Lined Snake (<i>Tropidoclonion lineatum</i>)	Prairie
Three-toed Box Turtle (<i>Terrapene triunguis</i>)	
Ornate Box Turtle (<i>Terrapene ornata</i>)	Prairie

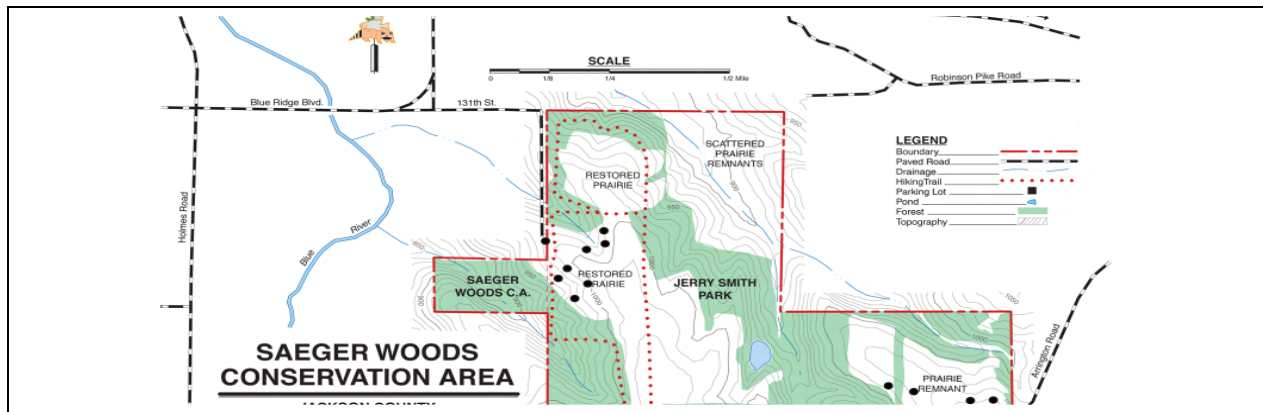


Figure 1. Map of Jerry Smith Park, Jackson County, Missouri. Dots mark locations of coverboard arrays.

When an animal was captured, we identified and marked it with a unique code using a medical cauterizer (Winne et al. 2006). For each individual captured, we measured length and weight by respectively using a tape measure and/or clear ruler and a spring scale (Pesola AG, Baar, Switzerland), body and substrate temperatures using a digital thermometer (Fluke 52 series; Fluke Corp., Everett, Washington), and determined sex by probing.

We used StatView 5.0 (SAS Institute, Cary, North Carolina, USA) for statistical analyses. We used a Friedman test to compare cover-object use by Ring-necked Snakes (the only species for which we had sufficient data to employ a statistical analysis) and a paired t-test to compare cover-object use by large and small species of reptiles. For all tests, $\alpha = 0.05$.

Results

During the three-year study (2013–2015), we captured 195 individuals of eight species (six snakes, one lizard, one turtle; Table 2). We found no prairie-limited species and only two of ten prairie-associated species (Table 2).

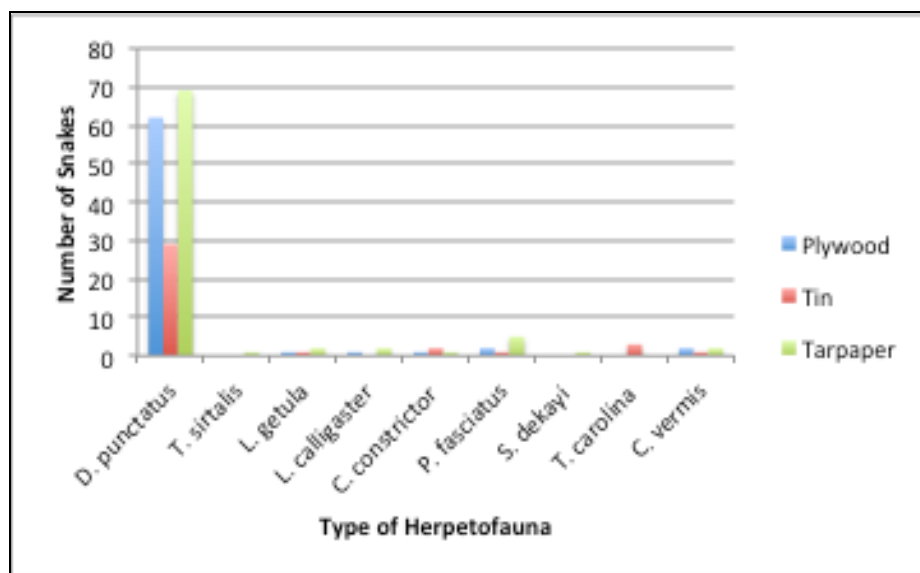


Fig. 2. Frequency of each reptilian species under each type of ACO

Encounters were more frequent in spring (N = 58) and fall (N = 113) compared to summer (N = 24). We collected proportionately more adult females than males in the summer (M:F = 7:17) and fall (39:74) compared to spring (25:33). By far the most data were recorded for Ring-necked Snakes (N = 160), which we encountered more frequently in spring (N = 47) and fall (N = 92) than in the summer (N = 21). Although we found male, female, and juvenile Ring-necked Snakes in approximately equal numbers (Table 2), juveniles of all species were encountered mainly in the early fall (N = 18).

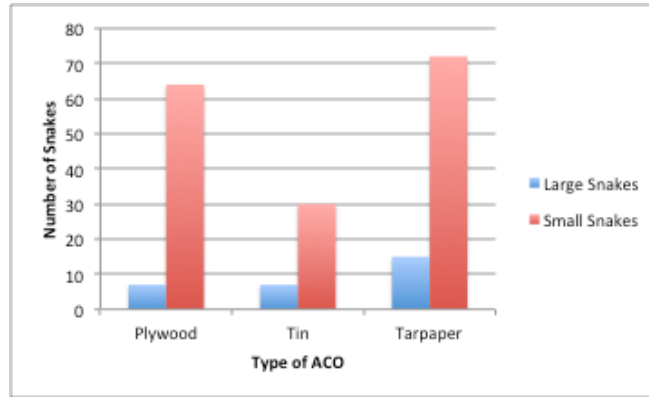


Fig. 3. Comparison of large versus small snakes under each type of ACO.

Table 2. Reptilian species encountered during this study. Some totals will not add up since size measurements were not available for all animals. Missing data are indicated by m-dashes (—).

	No. Captured	Sex Ratio (M:F:J)	Mean SVL (cm)	Mean Mass (g)
<i>Diadophis punctatus</i>	78	27:26:25	243.2	5.4
<i>Lampropeltis holbrooki</i>	4	0:4:0	396.3	32.8
<i>Lampropeltis calligaster</i>	1	0:1:0	283.0	17.8
<i>Carphophis vermis</i>	3	3:0:0	217.0	6.8
<i>Plestiodon fasciatus</i>	3	1:1:1	63.7	7.2
<i>Thamnophis sirtalis</i>	1	—	—	—
<i>Coluber constrictor</i>	4	—	—	—
<i>Storeria dekayi</i>	1	—	—	—
<i>Terrapene triunguis</i>	3	—	—	—

Because data on cover-object use for species other than Ring-necked Snakes were insufficient for statistical analysis (Fig. 2), we grouped cover-object use into that by small and large snakes. Large species were *Lampropeltis holbrooki*, *L. calligaster*, *Thamnophis sirtalis*, and *Coluber constrictor*; small species were *Diadophis punctatus*, *Carphophis vermis*, and *Storeria dekayi*. Cover-object use by large and small snakes (Fig. 3) did not differ significantly (Paired t-test; df = 2, t = -4.03, P = 0.056). Although *Diadophis punctatus* used tarpaper more and tin less frequently than other cover objects (Fig. 4), the differences were not significant (Friedman test; $\chi^2 = 4.67$, P = 0.097).

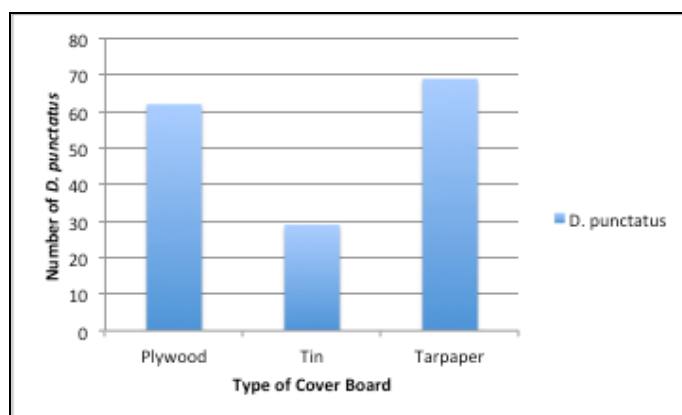


Fig. 4. Cover-object use by Ring-necked Snakes (*Diadophis punctatus*).

Discussion

Our prediction that reptilian species diversity in the restored prairie would mirror that of native prairies in the area was not supported. All of the reptiles encountered during this study are known to occur on prairies (Table 1). However, we encountered none of the prairie-limited species, suggesting that these species did not survive the degradation of the original prairie habitat and the reduction of remnant patches to very small areas, and were unable to recolonize restored habitat due to unsuitable intervening habitat.

Extensive development in western Jackson County, Missouri, and Johnson and Wyandotte Counties, Kansas, essentially destroyed any corridors that might have been used by prairie species. Although the more extensive restored prairie habitat at Jerry Smith Park likely is suitable for native prairie-limited species, the only means of reestablishing populations might be via human-mediated introductions, such as repatriation, relocation, or translocation (RRT) programs (e.g., Dodd and Seigel 1991).

Coleman and Sievert (2013) used similar methods during a study near Americus, Kansas and found mostly prairie (4 of 9 species and 193 of 420 individuals) or prairie-limited (2 species and 172 individuals) species. One additional species, the Speckled Kingsnake, a largely woodland species that will sometimes venture into prairies, was encountered in both studies, and is probably best explained by the proximity of forested pockets in both areas. The other two species encountered by Coleman and Sievert (2013) are semiaquatic and were found near riparian corridors. That they encountered more prairie and prairie-limited species is almost certainly best explained by the fact that their study was on a prairie reservation in a rural area not affected by urbanization, whereas our study was on an isolated patch of remnant and restored prairie habitat.

The abundance of Ring-necked Snakes in our study corresponds to data collected over five decades at a site near Lawrence, Kansas (Fitch 1998). Coleman and Sievert (2013) found mainly Great Plains Skinks, a prairie-limited species, but Ring-necked Snakes were nearly as abundant.

Our second prediction, that reptiles would be most frequently encountered under wood cover objects also was not supported. Ring-necked Snakes, apparently the most abundant reptilian species in the park, used tarpaper most frequently, although the differences were not significant. This corresponds to data presented by Coleman and Sievert (2013), in which reptiles showed no significant preference for any particular type of cover object, although small snakes (including Ring-necked Snakes) used tarpaper significantly more frequently than large snakes, which differed from our results. We had insufficient data on other species to draw definitive conclusions, but both small and large snakes used tarpaper most frequently, although, as for Ring-necked Snakes, the differences in ACO use were not significant. At least some of the apparent preference for tarpaper and, to a lesser extent plywood, might be attributable to the fact that these cover objects were flat and in contact with the substrate. This would facilitate contact between the snake and both the substrate and cover object. Because snakes are known to be thigmotactic (e.g.,

Greene and Mason 2005), this attribute might explain the lower usage rates of tin, the corrugations of which presumably reduced opportunities for contact.

Observations of more females in summer and fall versus more males in the spring probably reflected the fact that males leave their dens first in the spring followed later by females. That and males ranging widely in search of mates could account for the relative abundance of males in the spring (e.g., Fitch 1998; Richardson et al. 2006; and references therein). That most juveniles were found during the fall is most likely due to reproduction in the spring and birth or hatching in early fall (e.g., Fitch 1998; Richardson et al. 2006; and references therein).

One goal of this research was to determine if any prairie-limited herpetofaunal species were present. They were not, but we suggest that the remnant and restored prairie is viable for many reptilian species, which raises the question whether (re)introductions of native prairie species are feasible and appropriate. However, suitability of habitat requires consideration of many factors beyond the extent and quality of habitat and the presence or absence of natural corridors (e.g., van Andel and Aronson 2006). Consequently, reintroductions of certain wildlife, especially reptiles, can sometimes be controversial and are known to have low success rates (e.g., Germano and Bishop 2009; Ewen et al. 2013). Therefore, basing such decisions on adequate research is critically important.

Coverboard studies frequently are used to monitor or survey populations of herpetofauna (Hampton 2007), thus any understanding of how herpetofauna exploit ACOs and data on biases by certain species for different types of coverboards could help area managers make appropriate decisions regarding ongoing habitat management or what if any species should be (re)introduced into an area.

Acknowledgements

We thank Robert Powell for his time, guidance, and support. Larry Rizzo, Missouri Department of Conservation, and the Kansas City Parks and Recreation Department, arranged access to Jerry Smith Park and granted permission to conduct this research.

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Basking *Graptemys ouachitensis*. Table Rock Lake (UMC 3425P). Photo by B. Edmond.

ADDITIONS TO THE BIBLIOGRAPHY OF HERPETOFAUNAL REFERENCES FOR MISSOURI

Compiled by
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The following is a list of publications dealing with the biology of amphibians and reptiles from Missouri that have been brought to the attention of the author since the publication of Daniel (2016). Readers are requested to notify the author of any additional references that should be included in future compilations.

- Barrett, K., J.A. Crawford, Z. Reinstein, and J.R. Milanovich. 2017. Detritus quality produces species-specific tadpole growth and survivorship responses in experimental wetlands. *Journal of Herpetology* 51(2): 227-231.
- Crawford, J.A., C.A. Phillips, W.E. Peterman, I.E. MacAllister, N.A. Wesslund, A.R. Kuhns and M.J. Dreslik. 2017. Chytrid infection dynamics in cricket frogs on military and public lands in the midwestern United States. *Journal of Fish and Wildlife Management* 8(2):344-352.
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- Phillips, J.G., D.B. Fenolio, S.L. Emel and R.M. Bonett. 2017. Hydrologic and geologic history of the Ozark Plateau driving phylogenomic patterns in a cave-obligate salamander. *Journal of Biogeography* 44(11): 2463-2474.
- Praschag P, F. Ihlow, M. Flecks, M. Vamberger, U. Fritz. 2017. Diversity of North American map and sawback turtles (Testudines: Emydidae: Graptemys). *Zoologica Scripta* 2017: 1-8. <https://doi.org/10.1111/zsc.12249>
- Richardson, C., T. Messa and M.S. Mills. 2017. Testing the effectiveness of bait types on trapping freshwater turtles in Missouri. *Herpetological Review* 48(2): 331-333.
- Riedle, D.J., T. Weiberg, F. King-Cooley, S. Johnson, T.D.H. Riedle and D. Asahl. 2017. Observations of the population ecology of Three-toed Box Turtles in small urban forest fragments. *Collinsorum* 6(2-3): 10-14.

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ADDENDUM: RECENT HERPETOLOGICAL THESES FROM MISSOURI STATE UNIVERSITY

Compiled by

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Compiled here is a list of theses related to herpetology produced at Missouri State University, Springfield MO, since Greene (2000) published a similar list for the university (named Southwest Missouri State University at the time). A searchable database of all Missouri State University graduate works can be found at <https://bearworks.missouristate.edu/>.

- Anders, B. 2008. Influence of ultraviolet light, righting response, and community structure in aquatic turtles. Advisor: D. Moll.
- Anderson, K.A. 2016. Friends in Low Places: Responses of a benthic stream fish to intra-guild alarm cues. Advisor: A. Mathis.
- Anthony, T. L. 2013. Aquatic turtle community dynamics in relation to reintroduction of Alligator Snapping Turtles, *Macrochelys temminckii*. Advisor: D. Ligon.
- Barrett, R. 2002. The effect of spatial subsidies on the diet, density, and species richness of insular lizards in the Gulf of California. Advisor: A. Wait.
- Benbow, G.T. 2008. Habituation, scent-trailing, and effects of temperature upon the strike-induced chemosensory searching (SICS) in the Cottonmouth (*Agkistrodon piscivorus*). Advisor: B. Greene.
- Bortosky, R.C. 2014. Honest signaling in aggressive contests between Ozark Zigzag Salamanders (*Plethodon angusticlavius*). Advisor: A. Mathis.
- Brennan, A.M. 2004. The effect of temperature and digestion on metabolism in Black Rat Snakes, *Elaphe obsoleta obsoleta*. Advisor: B. Greene.
- Brinkman, L.C. 2016. Natural history and conservation of Bolitoglossine Salamanders in central Panama. Advisor: B. Greene.
- Churilla, J.M. 2015. Behavioral and physiological evidence for musk gland secretions as a chemical alarm cue in the Cottonmouth, *Agkistrodon piscivorus*. Advisor: B. Greene.
- Combs, R.D. 2007. Comparative phylogenetic analysis in populations of the Western Cottonmouth (*Agkistrodon piscivorus leucostoma*) distributed in three North American drainage basins. Advisor: M. McKnight.
- Crane, A.L. 2005. The effect of reproductive condition on the thermal and spatial ecology of the female Cottonmouth (*Agkistrodon piscivorus*) in southwest Missouri. Advisor: B. Greene.

- Dalton, B. D. 2013. Identification of sex and parasitism via chemical cues by the Ozark Zigzag Salamander. Advisor: A. Mathis.
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- East, M.B. 2012. Diet and feeding behavior of juvenile Alligator Snapping Turtles (*Macrochelys temminckii*) in eastern Oklahoma. Advisor: D. Ligon.
- Elbers, J.P. 2010. Effect of ingestion by Alligator Snapping Turtles (*Macrochelys temminckii*) on seeds of riparian vegetation. Advisor: D. Moll.
- Evans, W.L. 2012. Effects of temperature on foraging, endurance, and sprint speed in *Agkistrodon piscivorus* and *Nerodia sipedon*. Advisor: B. Greene.
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- Friesen, R. R. 2017. Spatial learning of shelter locations and associative learning of a foraging task in the Cottonmouth, (*Agkistrodon piscivorus*). Advisor: B. Greene.
- Gall, B. G. 2008. Predator-prey interactions between Hellbenders (*Cryptobranchus alleganiensis alleganiensis* and *C.a. bishopi*) and native and nonnative fishes. Advisor: A. Mathis.
- Green, M.D. 2006. Nest emergence and chemosensory mediated predator avoidance: two studies of behavior in the Red-Eared Slider (*Trachemys scripta elegans*). Advisor: D. Moll.
- Helton, E.J. 2013. Learning of dietary cues by embryos and larvae of Ringed Salamanders (*Ambystoma annulatum*). Advisor: A. Mathis.
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- Nelson, N.A. 2007. Genetic, morphological, and behavioral analysis of the Oklahoma Salamander (*Eurycea tynerensis*) in southwestern Missouri. Advisor: M. McKnight.

- Parsons, J.K. 2010. Effects of prior exposure to predatory chemical cues on territorial and foraging behaviors of the Ozark Zigzag Salamander, *Plethodon angusticlavius*. Advisor: A. Mathis.
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- Ray, W.M. 2004. Predatory strike behaviors of the Western Cottonmouth, *Agkistrodon piscivorus leucostoma*. Advisor: B. Greene.
- Reeder, T.W. 2013. A behavioral syndrome in the Southern Red-Backed Salamander (*Plethodon serratus*). Advisor: A. Mathis.
- Rudolph, L. J. 2015. Variation in behavior of different populations and sex classes of paedomorphic Oklahoma Salamanders. Advisor: A. Mathis.
- Sanders, T.R. 2011. Physiological plasticity and ecology of the Yellow Mud Turtle (*Kinosternon flavescens*) during hibernation. Advisor: D. Ligon.
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